A Replication Study- Postoperative Complications in Bariatric Surgery Using Age and BMI Stratification: A Study using ACS-NSQIP data (2014)

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A replication study proposal has been submitted to meet the requirements of the Master of Public Health Capstone project at the University of Nebraska Medical Center College of Public Health.

Replicated Article:
Sanni, A., Perez, S., Medbery, R. *et al.* Postoperative complications in bariatric surgery using age and BMI stratification: a study using ACS-NSQIP data. *Surg Endosc* **28**, 3302–3309 (2014). https://doi.org/10.1007/s00464-014-3606-7

Abstract:

This study aims to replicate the findings of Sanni et al.'s (2014) research on postoperative complications in bariatric surgery patients. The original research utilized age and BMI stratification and data from the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) to identify the relationship between these variables and postoperative complications. The findings of the original study revealed significant associations between age, BMI, and postoperative complications. The replication plan aims to confirm these associations and identify the factors that lead to postoperative complications in patients undergoing bariatric surgery. The replication study proposes a comprehensive plan consisting of three types of analyses: pure replication, measurement and estimation analysis (MEA), and theory of change analysis (TCA). These analyses are designed to validate and expand on the discoveries of the original study.

The pure replication phase is a critical step in the replication process, aiming to reproduce the original analyses accurately. This phase involves performing the statistical tests used in the original study to confirm the significant risk factors identified in the original study. Overall, the pure replication phase ensures the accuracy of the research findings.

Conducting MEA (Measurement and Estimation Analysis) is crucial for ensuring the accuracy and reliability of the findings. Employing alternative methods such as nonparametric tests will provide a more comprehensive analysis and help validate the results obtained in the pure replication phase. It is important to ensure that the conclusions drawn from the original study are robust and can be replicated using different statistical techniques. The concluding step, TCA (Theory of Change Analysis), will broaden the scope of the original study by examining the correlation between wound complications and diabetes status (YES/NO) among patients undergoing bariatric surgery. This analysis will employ Chi-Square tests and logistic regression

models to assess the association between diabetes and wound complications among patients undergoing bariatric surgery while accounting for variables including age and BMI.

Through replicating the original study's findings and employing alternative analytical approaches, this research aims to enhance understanding of the determinants influencing postoperative complications among individuals undergoing bariatric surgery. Furthermore, by exploring novel inquiries concerning wound complications in patients with diabetes, this study aspires to inform the establishment of evidence-driven protocols for bariatric surgery selection criteria, thereby fostering advancements in patient care and outcomes.

Introduction: The study selected for replication is “Postoperative Complications in Bariatric Surgery Using Age and BMI Stratification” by Aliu Sanni, Sebastian Perez, Rachel Medbery, Hernan D. Urrego, Craig McCready, Juan Toro, Ankit D. Patel, Edward Lin, John F. Sweeney & S. Scott Davis Jr. examining the risk associated with Bariatric surgery with an increase in age and BMI. Bariatric surgery is a surgical procedure that involves altering the gastrointestinal system to help people lose weight and improve their overall health. This type of surgery is typically recommended for people who are severely obese and have not been able to lose weight through traditional methods such as diet and exercise. Bariatric surgery has been proven to be an effective way to achieve long-term weight loss and reduce the risk of health problems associated with obesity, such as diabetes, heart disease, and sleep apnea (The American Society for Metabolic and Bariatric Surgery). This study aimed to examine the complications associated with bariatric surgery based on age and BMI stratification by using ACS-NSQIP data. This study investigates the association between increasing age, body mass index (BMI), and the trends in morbidity and mortality in patients undergoing elective laparoscopic adjustable banding (LAGB), sleeve gastrectomy (LSG), and gastric bypass (LGBP) procedures. The goal of the researchers is to identify patterns and correlations that can guide Bariatric surgery decision-making and improve patient outcomes.

Insights about the risk factors linked with bariatric surgery and their influence on postoperative outcomes are presented by analyzing data from the American College of Surgeons National Surgical Quality Improvement Program (ACS/NSQIP) 2010-2011 Public Use File. The data is derived from a comprehensive, prospective, multi-hospital database, which accumulates information from patients undergoing both inpatient and outpatient surgical procedures across more than 250 participating medical centers. The research examined information collected from 20,308 individuals who were 18 years of age or older and had received bariatric surgery. The surgeries consisted of laparoscopic gastric bypass, laparoscopic sleeve gastrectomy, or laparoscopic adjustable gastric banding. The study excluded patients with a BMI below 35 kg/m^2, those who had undergone emergency surgeries, those with a cancer history, and those who had received combined procedures. Statistical analyses were conducted using Fisher's exact test and logistic regression.

The study found that older age and higher BMI are linked to higher rates of illness and death after bariatric surgery. Factors like chronic obstructive pulmonary disease (COPD), hypertension, diabetes, and dyspnea increase the risk of postoperative complications. Bariatric surgery can lead to various complications, such as gastroesophageal perforation, bleeding, acute stomal obstruction, oesophageal dilation, gallstone formation, nutritional deficiencies, vomiting, and incisional hernia (Ma, I. T., 2015). Although the study only examined short-term outcomes within 30 days after surgery, its large sample size and analysis of various perioperative variables make it an important resource for understanding the complex factors that impact outcomes after bariatric surgery.

The results from the study found that higher BMI and advancing age increase the risk of postoperative complications, with major contributors to postoperative morbidity including COPD, Diabetes, Hypertension, and Dyspnea, and LGBP and LSG procedures having a higher likelihood of complications compared to LAGB, revealing overall mortality and morbidity rates of 0.11% and 3.84%, respectively, with a notable increase in the odds of postoperative complications associated with advancing age and higher BMI, providing valuable insights for preoperative counseling and evaluation of surgical candidacy for bariatric surgical patients and offering critical information for evidence-based decision-making in this field.

Methods:

Pure Replication: The findings and statistical analyses presented in this article will be replicated by utilizing the raw data available from the ACS NSQIP participant use data file, and reported statistical methods as a pure replication. Throughout the replication process, we aim to replicate the results obtained in Tables 1, 2, 3, 4, 5, and Figure 1 of the original paper. We will utilize the same methods outlined in the original article to replicate the results for Table 1 to Table 5, which compare or generate data for the three surgery groups. The statistically significant results observed across all three types of surgeries—LGBP, LSG, and LAGB—will be confirmed. As part of the task, we will attempt to recreate Figures 2 and 3. It should be noted that replicating these figures is optional and not mandatory for completing the task.

SAS software will be used to replicate the original analysis exactly. An independent sample t-test was used to calculate the original analysis for continuous variables such as age and BMI in demographics. On the other hand, the Chi-square test was used for categorical variables like gender and age. Due to small sample sizes, Fisher's exact test was employed to compare categorical variables.

Researchers utilized binary logistic regression to comprehensively examine the influence of age and BMI on post-bariatric surgery complication rates. This analysis involved adjusting for potential confounding variables and exploring interaction terms and second-order squared terms for age and BMI. Additionally, the impact of surgery year was investigated as a potential confounder to ensure consistency in complication rates. Variables were deemed potential confounders if they exhibited a significant effect on complications in univariate analysis at a significance level of ($p < 0.05$). This rigorous modeling approach allowed for a thorough understanding of the relationship between age, BMI, and post-bariatric surgery complications, while also considering potential interactions

Measurement and Estimation Analysis: In the MEA additional analyses will be performed to ensure their robustness.There are alternative methods available for analyzing data when comparing three groups, rather than a t-test. One such method is Analysis of Variance (ANOVA), which can be used to compare continuous variables such as demographics (e.g. age and BMI) across three categories: LGBP, LSG, and LAGB. This can be achieved by utilizing general linear models or the PROC GLM procedure. Tukey's method for multiple comparisons was employed to assess the differences among the means of the three groups: LGBP, LSG, and LAGB. This approach automatically adjusts for multiple comparisons to control the family-wise error rate. This method helps to determine the average effects of three or more procedures, which can be useful in deciding which procedures are better or worse while controlling the probability of making an incorrect decision. In Table 2, a comprehensive set of SAS procedures was utilized to explore various variables. PROC FREQ was employed to assess morbidity, mortality, and the association between "returnor" (return to operation) and procedure using a chi-square test. To analyze "Optime" (operation time), PROC MEANS was used as the original method, while PROC NPAR1WAY served as an alternative approach to verify the reliability of the original statistical method. Additionally, considering the comparison between the three groups, the Kruskal-Wallis test, a nonparametric test, would be more appropriate than PROC MEANS.

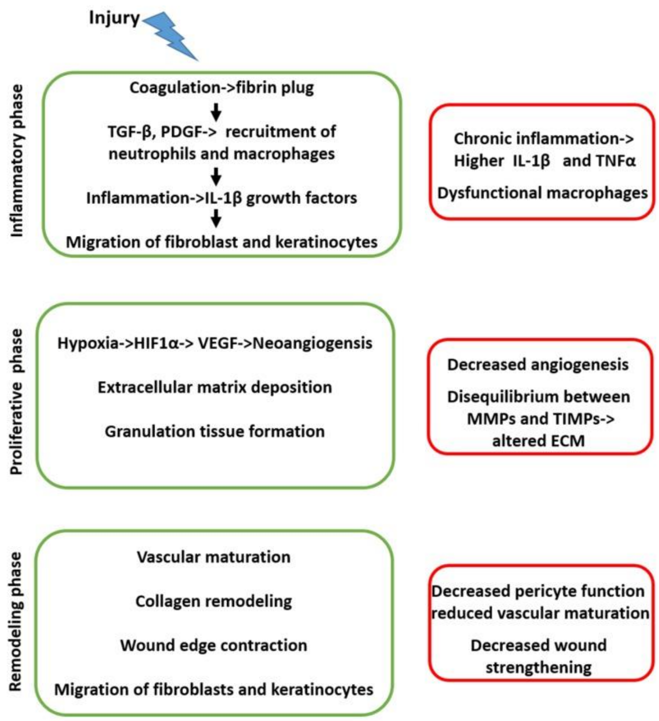
Regarding the variable Length of Stay (LOS), the most reasonable method to determine if there is a statistically significant difference between the medians of three categories of bariatric surgery (LGBP, LSG, and LAGB) is the Kruskal-Walli’s test. This non-parametric method can be used to assess whether there is a significant difference between the bariatric surgery category groups for a continuous variable, Length of Stay. The SAS procedure, PROC NPAR1WAY, will be utilized to test whether the distribution of the variable, Length of Stay, is the same across different groups.

The evaluation will also involve a comprehensive analysis of Table 5 to replicate the identified risk factors for postoperative complications following bariatric surgery, as delineated in the original study. This table presents detailed data on complication rates among patients undergoing different bariatric procedures, including LGBP, LSG, and LAGB. Specifically, the incidence of complications will be examined across various patient characteristics, such as ASA class, diabetes status, dyspnea, COPD, and HTN. The statistical significance of these associations will be determined using p-values. Replicating Table 5 is essential to ensure the consistency and reliability of the original study's findings regarding the relationship between these variables and postoperative complications.

Theory of Change Analysis: The article centers around analyzing the patterns of postoperative complications in bariatric surgery by categorizing patients based on age and BMI. I would like to expand on this study by delving into the wound complications among individuals who have chronic health conditions such as diabetes, which is known to escalate with age and BMI. Specifically, the TCA aims to investigate if there is an association between wound healing complications and diabetes status (Insulin, Non-insulin or no-diabetes).

In the original study, the authors analyzed the wound complications that arose in three different bariatric surgery procedures - LGBP, LSG, and LAGB. The study listed four categories of wound complications, including superficial infections, organ space infections, deep-site infections, and wound dehiscence. Upon analyzing the data, it was found that there was a significantly higher incidence of superficial and organ space infections in the LGBP group as compared to either the LSG or LAGB groups. However, there was no significant difference observed in the incidence of deep-site infections and wound dehiscence among the three groups. These findings suggest that while certain types of bariatric surgery may be associated with a higher risk of wound complications, the incidence of such complications may vary depending on the specific type of procedure performed. The image presented below provides a comprehensive overview of the series of events that sequentially take place during the healing process of a wound in both physiological (green, left side) and diabetic (red, right side) conditions. The physiological wound healing process involves various stages, including hemostasis, inflammation, proliferation, and remodeling, while diabetic wound healing is characterized by a delayed or impaired response to these stages. As a result, diabetic wounds take a longer time to heal and may lead to further complications (Spampinato, S.F., et al, 2020).

Figure 1: “Comparative Wound Healing: Normal vs Diabetic Individuals”



The relationship between diabetes and wound complications in bariatric surgery is a complex issue that tends to become more nuanced with increasing age and body mass index (BMI). To investigate this issue further, a plan to conduct an analysis that could potentially reveal valuable insights and intervention points. The chi-square test is employed to explore the potential relationship between diabetes (insulin, noninsulin, or non-diabetic) and the four wound complications observed in patients undergoing bariatric surgery. Additionally, we investigate whether an increase in age contributes to the risk of diabetes and assess for interactions between increasing body mass index (BMI) and diabetes status in a logistic regression model. A p-value of 0.05 or lower is considered statistically significant. This analytical approach aims to provide insights into the impact of diabetes on wound complications during bariatric surgery and may inform the development of more targeted interventions.

Pure Replication Results:

In the replication study, a discrepancy in sample size was observed compared to the original study. While the original study encompassed a sample size of 20,308, the replication study involved a sample size of 20,313. However, despite this slight disparity, several factors could potentially contribute to differences in sample sizes between the two studies. The observed variations in sample size likely stem from the ambiguity surrounding the inclusion criteria in the original study, potentially impacting the disparity in sample sizes observed.

After comparing the original study and the replication attempt for the analysis of demographic characteristics among patients undergoing various bariatric surgeries, consistent findings were observed. Significant differences in BMI, gender, race, inpatient status, and ASA class distribution among the surgical categories were identified in both studies. Although minor discrepancies were noted in some variables, such as the proportions of males and White individuals, and the distribution of ASA classes, the statistical significance and overall trends remained coherent between the original and replication studies. These results indicate that the replication effort successfully confirmed the reliability and validity of the original study's conclusions regarding the demographic profiles of patients undergoing different types of bariatric surgery.

Pure Replication Table 1A Demographics (20,313)				
Variable	LGBP (N=11,623)	LSG (N=3,067)	LAGB (N=5,625)	P Value
Age, mean year (sd)	43.8 (11.5)	43.7 (11.2)	44.0 (12.1)	0.6
BMI, mean kg/m^2 (sd)	46.6 (7.8)	46.7 (8.5)	44.2 (6.5)	**<0.0001**
Gender: male n (%)	2,365 (20.6%)	746 (24.3%)	1,317 (23.4%)	**<0.0001**
Race: white n (%)	8,383 (72.1%)	2,102 (68.5%)	4,115 (73.1 %)	**<0.0001**
Inpatient, n (%)	11,475 (98.7%)	2,846 (92.8%)	3,123 (55.5%)	**<0.0001**
ASA class				**< 0.0001**
1	51 (0.4%)	12 (0.4%)	37 (0.7%)	
2	4,098 (35.3%)	1,048 (34.2%)	2,327 (41.4%)	
3	7,203 (62.0%)	1,922(62.8%)	3,180 (56.5%)	
4	248 (2.1%)	81 (2.6%)	76 (1.4%)	

Bold values are statistically significant (P < 0.05)

Original Table 1B Demographics (20,308)				
Variable	LGBP (N=11,617)	LSG (N=3,069)	LAGB (N=5,622)	P Value
Age, mean year (sd)	43.8 (11.5)	43.7 (11.2)	44.0 (12.1)	0.6308
BMI, mean kg/m^2 (sd)	46.6 (7.8)	46.7 (8.4)	44.2 (6.5)	**< 0.0001**
Gender: male n (%)	2,365 (20.6%)	746 (24.6%)	1,318 (23.7%)	**<0.0001**
Race: white n (%)	8,382 (82.2%)	2,104 (75.9%)	4,115 (80.6%)	**<0.0001**
Inpatient, n (%)	11,469 (98.7%)	2,848 (92.8%)	3,121 (55.5%)	**<0.0001**
ASA class				**<0.0001**
1	51 (0.4%)	12 (0.4%)	37 (0.7%)	
2	4,097 (35.3%)	1,048 (34.2%)	2,325 (41.4%)	
3	7,199 (62.1%)	1,924 (62.8%)	3,179 (56.6%)	
4	247 (2.1%)	81 (2.6%)	76 (1.4%)	

*Bold values are statistically significant (P < 0.05). Red highlighting indicates where differences are observed.

Upon comparing the replication study's Table 2 with the original, consistent findings concerning postoperative complications among patients undergoing various bariatric surgeries were evident. The study examined variables such as mortality, reoperation rates, mean operation times (Optime), and length of hospital stay (LOS) across different surgical procedures. Although the original paper lacked a clear definition of the morbidity variable, efforts were made to replicate it along with its corresponding p-value. However, challenges were encountered in doing so, resulting in the exclusion of specific morbidity rates from the replication. The main challenge was the definition of morbidity. In the original paper, morbidity was given as a continuous variable, representing the predicted probability of morbidity in the dataset. No specific cutpoint was defined to categorize morbidity as a binary variable. Consequently, replicating the study became difficult as there was no clear threshold to classify morbidity, leading to its exclusion from the replication.

Despite this minor setback, the study's findings closely mirrored those of the original, with comparable mortality rates observed across all surgical procedures and no significant differences detected. Similarly, the rates of reoperation were consistent between the replication and the original study, although slightly higher rates were observed for LAGB. Mean operation times and median lengths of hospital stay remained consistent across surgical procedures, with slight variations noted, particularly for LSG and LAGB.

In conclusion, the replication effort effectively validates the original study's conclusions regarding postoperative complications among patients undergoing different types of bariatric surgery. This reaffirms the reliability and validity of the replication endeavor.

Pure Replication Table 2A Postoperative complications				
Variable	LGBP (N=11,623)	LSG (N= 3,067)	LAGB (N= 5,625)	P value
Morbidity, n (%)	N/A	N/A	N/A	N/A
Mortality, n (%)	19(0.2%)	3 (0.05%)	3 (0.1%)	0.1403
Reoperation, n (%)	256 (2.2%)	48 (1.6%)	55 (0.9%)	<0.0001
Optime, mean mins (sd)	126 (51.1)	92.6 (46)	62.3 (32)	<0.0001
LOS*, median days (IQR)	2.0 (1.0)	2.0 (1.0)	1.0 (1.0)	<0.0001

Bold values are statistically significant (P < 0.05)
*Operation time
*LOS length of stay
Red highlighting indicate where differences are observed.

Original Table 2B Postoperative complications				
Variable	LGBP (N= 11,617)	LSG (N=3,069)	LAGB (N= 5,622)	P value
Morbidity, n (%)	589 (5.1%)	98 (1.4%)	114 (3.7%)	<0.0001
Mortality, n (%)	19 (0.2%)	3 (0.1%)	3 (0.1%)	0.1401
Reoperation, n (%)	255 (2.2%)	48 (1.6%)	55 (1.0%)	<0.0001
Optime, mean mins (sd)	126.5 (50.6)	93.3 (45.9)	64.2 (31.5)	<0.0001
LOS*, median days (IQR)	2.0 (1.0)	2.0 (1.0)	1.0 (1.0)	<0.0001

Bold values are statistically significant (P < 0.05)
*Operation time
*LOS length of stay
Red highlighting indicate where differences are observed.

Upon comparing Table 3 of the replication study with the original research, coherence in the results concerning particular postoperative complications among patients undergoing different bariatric surgeries was evident. Both tables explored factors like pneumonia, re-intubation, pulmonary embolism, failure to wean, acute renal failure, renal insufficiency, urinary tract infection, cardiac arrest, myocardial infarction, bleeding, deep vein thrombosis, peripheral nerve injury, coma, and stroke/CVA across various surgical procedures.

The replication study closely resembled the outcomes of the original investigation, indicating similar occurrence rates of specific postoperative complications across all surgical procedures. While slight divergences may exist in certain aspects, such as acute renal failure and renal insufficiency, the overall statistical significance and trends remained consistent. For instance, both the replication and original tables highlighted renal insufficiency as a significant complication for LSG, notwithstanding minor variations in the rates of acute renal failure.

These findings imply that the replication endeavor effectively echoes the original study's conclusions regarding particular postoperative complications in a diverse cohort of bariatric surgery patients. This underscores the credibility and precision of the replication study.

Pure Replication Table 3A Specific postoperative complications				
Variable	LGBP (N= 11,617)	LSG (N= 3,069)	LAGB (N=5,622)	P value
Pneumonia	50 (0.43%)	10 (0.33%)	9 (0.16%)	**0.0166**
Re-intubation	46 (0.40%)	10 (0.33%)	4 (0.07%)	**0.0011**
Pulmonary embolism	28 (0.24%)	5 (0.16%)	2 (0.04%)	**0.0095**
Failure to wean	27 (0.23	7 (0.03%)	2(0.04%)	**0.0121**
Acute renal failure	12 (0.10%)	4 (0.13%)	1 (0.02%)	0.0702
Renal insufficiency	10 (0.09%)	9 (0.29%)	2 (0.04%)	**0.0011**
Urinary tract infection	82 (0.71%)	19 (0.62%)	19 (0.34%)	**0.0124**
Cardiac arrest	9 (0.08%)	2 (0.07%)	2 (0.04%)	0.6323
Myocardial infarction	11(0.09%)	2 (0.07%)	1 (0.02%)	0.1820
Bleeding	153 (1.32%)	15 (0.49%)	6 (0.11%)	**<.0001**
Deep vein thrombosis	19 (0.16%)	14 (0.46%)	5 (0.09%)	**0.0005**
Periph nerve injury	3 (0.03%)	0 (0.0%)	0 (0.0%)	0.7281
Coma	1 (0.01%)	0 (0.0%)	0 (0.0%)	1.0
Stroke/CVA	4 (0.03%)	1 (0.03%)	0 (0.0%)	0.4378

Bold values are statistically significant (P < 0.05)

Red highlighting indicates where differences are observed.

Original Table 3B Specific postoperative complications				
Variable	LGBP (N= 11,617)	LSG (N= 3,069)	LAGB (N=5,622)	P value
Pneumonia	50 (0.43%)	10 (0.33%)	9 (0.16%)	**0.0166**
Re-intubation	46 (0.40%)	10 (0.33%)	4 (0.07%)	**0.0011**
Pulmonary embolism	28 (0.24%)	5 (0.16%)	2 (0.04%)	**0.0095**
Failure to wean	27 (0.23%)	7 (0.23%)	2 (0.04%)	**0.0121**
Acute renal failure	12 (0.10%)	4 (0.13%)	1 (0.02%)	0.0703
Renal insufficiency	10 (0.09%)	9 (0.29%)	2 (0.04%)	**0.0011**
Urinary tract infection	82 (0.71%)	19 (0.62%)	19 (0.34%)	**0.0124**
Cardiac arrest	9 (0.08%)	2 (0.07%)	2 (0.04%)	0.6324
Myocardial infarction	11 (0.09%)	2 (0.07%)	1 (0.02%)	0.1822
Bleeding	153 (1.32%)	15 (0.49%)	6 (0.11%)	**<0.0001**
Deep vein thrombosis	19 (0.16%)	14 (0.46%)	5 (0.09%)	**0.0005**
Periph nerve injury	3 (0.03%)	0 (0.0%)	0 (0.0%)	0.7282
Coma	1 (0.01%)	0 (0.0%)	0 (0.0%)	1.0
Stroke/CVA	4 (0.03%)	1 (0.03%)	0 (0.0%)	0.4379

*Bold values are statistically significant (P < 0.05)

Red highlighting indicates where differences are observed.

Upon comparing Table 4 of the replication study with the original research, remarkable consistency in the findings regarding wound complications among patients undergoing various bariatric surgeries was evident. Both tables explored variables like superficial site infection, deep site infection, organ space site infection, and wound dehiscence across different surgical procedures.In summary, the replication study closely mirrored the results of the original investigation, revealing similar rates of wound complications across all surgical procedures. While slight variations may exist in certain aspects, such as the incidence of deep site infection, the overall statistical significance and trends remained unchanged. For instance, both the replication and original tables underscore organ space site infection as a significant complication, despite minor differences in rates among surgical procedures.These findings suggest that the replication effort effectively reinforces the conclusions drawn from the original study regarding wound complications in patients undergoing diverse bariatric surgeries. This emphasizes the reliability and credibility of the replication study.

Pure replication Table 4A Wound complications				
Wound complication	LGBP (N= 11,617)	LSG (N=3,069)	LAGB (N=5,622)	P value
Superficial site infection	185 (1.59%)	30 (0.98%)	45 (0.80%)	**<0.0001**
Deep site infection	17 (0.15%)	1 (0.03%)	3 (0.05%)	0.0854
Organ space site infection	65 (0.56%)	22 (0.72%)	5 (0.09%)	**<0.0001**
Wound dehiscence	9 (0.08%)	1 (0.03%)	4 (0.07%)	0.8670

*Bold values are statistically significant (P < 0.05)

Organ space infection-anastomotic or staple line leaks

Deep site infection-infections of the fascial and muscle layers

Red highlighting indicate where differences are observed.

Original Table 4B Wound Complications				
Wound complication	LGBP (N= 11,617)	LSG (N=3,069)	LAGB (N=5,622)	P value
Superficial site infection	185 (1.59%)	30 (0.98%)	45 (0.80%)	**<0.0001**
Deep site infection	17 (0.15%)	1 (0.03%)	3 (0.05%)	0.0852
Organ space site infection	65 (0.56%)	22 (0.72%)	5 (0.09%)	**<0.0001**
Wound dehiscence	9 (0.08%)	1 (0.03%)	4 (0.07%)	0.8670

*Bold values are statistically significant (P < 0.05)

Organ space infection-anastomotic or staple line leaks

Deep site infection-infections of the fascial and muscle layers

Red highlighting indicates where differences are observed.

Challenges arose in replicating Table 5 due to insufficient clarity regarding the definition of the outcome variable (postoperative complications) and the methodology used for its creation. Despite diligent efforts to reconstruct this variable, the absence of specific guidance hindered replication endeavors.

Recognizing the pivotal role of Table 5 in the study on identifying risk factors for increased postoperative complications following bariatric surgery, ensuring their accuracy and consistency is paramount. For the replication study, the postoperative complications outcome variable was created using the following variables: procedure comparisons (sleeve vs. band, bypass vs. band), ASA class (asaclass), presence of chronic obstructive pulmonary disease (COPD), dyspnea, hypertension, diabetes, and mortality; if any of these listed variables were present, the subject was indicated as having postoperative complications.

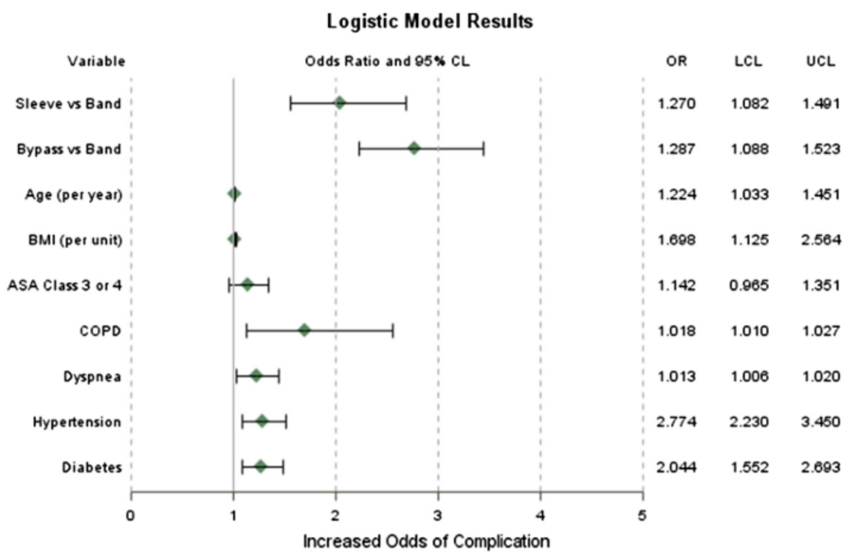
In the original study on postoperative complications following bariatric surgery, a comprehensive analysis identified several key risk factors contributing to adverse outcomes. Among these were prevalent comorbidities such as diabetes, hypertension, dyspnea, and chronic obstructive pulmonary disease (COPD). The study further elucidated that the likelihood of experiencing postoperative complications increased incrementally with age and body mass index (BMI), with each additional year and BMI point correlating with elevated odds of complications. Particularly noteworthy were the findings regarding different surgical procedures: patients undergoing Laparoscopic Gastric Bypass (LGBP) were found to face three times higher odds of complications compared to those opting for Laparoscopic Adjustable Gastric Banding (LAGB), while patients undergoing Laparoscopic Sleeve Gastrectomy (LSG) faced double the risk.

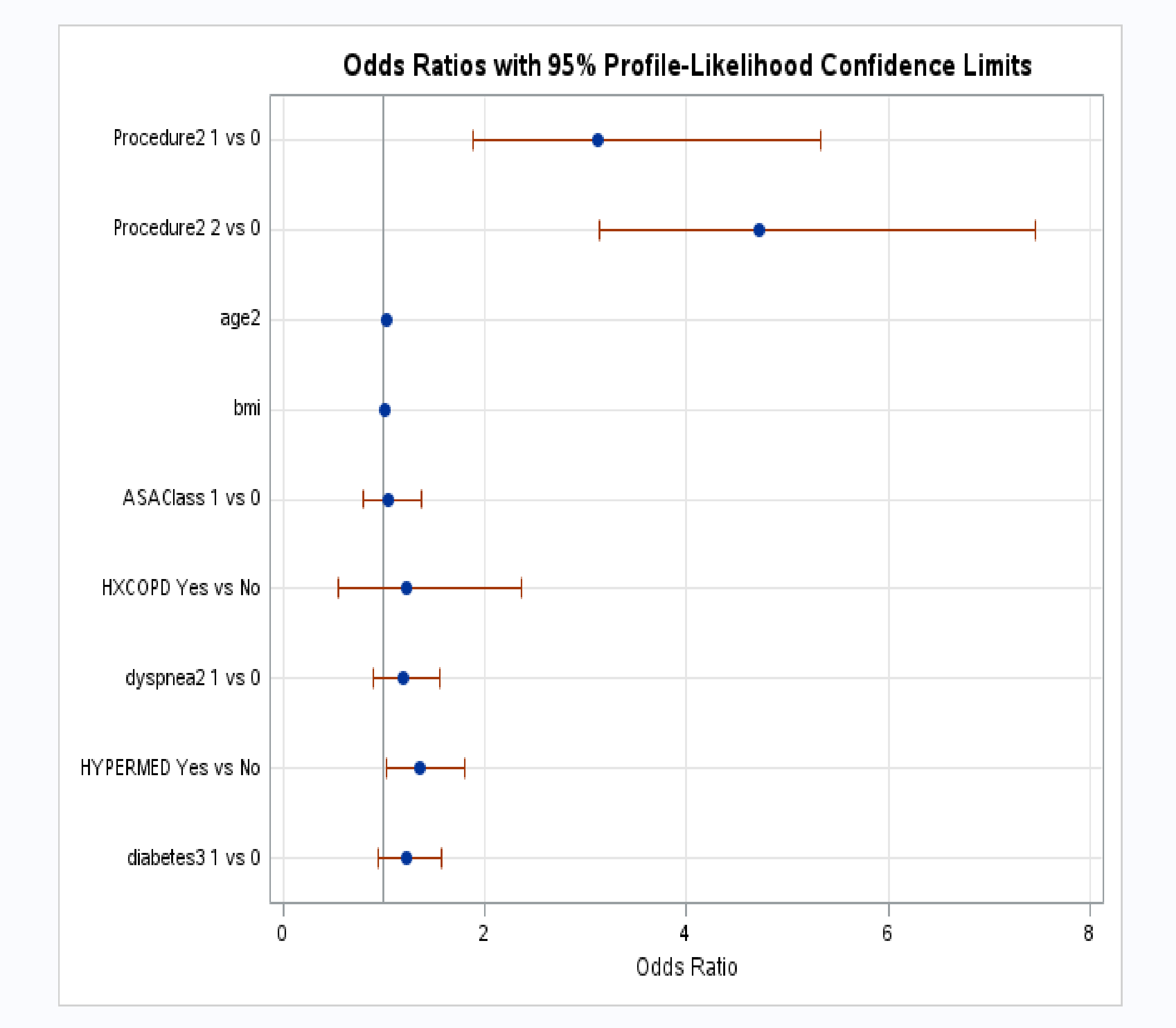
In contrast, the replication study yielded somewhat disparate results, shedding new light on the multifaceted landscape of post-bariatric surgery complications. Notably, while Procedure2 i.e., sleeve vs band, bypass vs band, age, and hypertension retained significance as risk factors for complications, however, some variables, such as diabetes, ASAclass and COPD, which were identified as significant risk factors in the original study, did not demonstrate statistically significant associations with postoperative complications in this analysis.

The variation observed between the original study and the replication results hints at potential differences in methodology, sample size, or population characteristics that might influence the variables' impact on post-bariatric surgery complications. Furthermore, it's worth noting that the original study lacked clarity regarding the specific variables considered when creating the complications variable.

ORIGINAL STUDY: LOGISTIC REGRESSION TABLE

Fig. 1 Logistic regression results. The logistic regression model identified diabetes, hypertension, dyspnea, and COPD as important risk factors for postoperative complications following bariatric surgery. Postoperative complications were two to three times more likely after LSG or LGBP when compared to LAGB, respectively





Here procedure2 (1 vs 0) = sleeve vs band and procedure2 (2 vs 0) =bypass vs sleeve

Table 5 Multilogistic Regression table of postoperative complications - replication analysis

Variable	Odds Ratio	95% Confidence Interval
Procedure2 (1 vs 0) (Sleeve vs Band)	3.127	(1.88,5.32)
Procedure2 (1 vs 0) (Bypass vs Band)	4.715	(3.13,7.46)
Age (per year)	1.022	(1.01,1.03)
BMI (per unit)	1.011	(0.99,1.02)
ASAclass	1.046	(0.80,1.37)
COPD	1.220	(0.54,2.35)
Dyspnea	1.184	(0.89,1.55)
Hypertension	1.358	(1.03,1.79)
Diabetes	1.216	(0.93,1.57)

In summary, the replication effort effectively validated the original study's conclusions regarding postoperative complications among patients undergoing different types of bariatric surgery, although the covariates in the multivariable model could not be replicated. This underscores the reliability and validity of the primary research question of the original study.

Method and Estimation Analysis:

Upon comparing the outcomes of the replication study with those of the original investigation, it becomes evident that distinct methodological strategies were employed to examine the connection between age and BMI across various bariatric procedures (LAGB, LGBP, LSG). Initially, the original study, utilizing the MEA Procedure, primarily relied on t-tests to discern differences in mean age among the procedure groups. However, recognizing the inherent limitations of t-tests for comparing multiple groups, the replication study opted for an alternative approach. PROC GLM was employed to conduct an analysis of variance (ANOVA) for both age and BMI assessments. ANOVA allows for the simultaneous comparison of means across multiple groups while controlling for potential confounding variables, providing a more comprehensive analysis compared to t-tests.

In the replication study, the ANOVA results for age unveiled no statistically significant differences across the procedure groups ($F(2, 20313) = 0.53$, $p = 0.5915$), in contrast to the original findings. Similarly, Tukey's HSD post hoc test in the replication study affirmed these results, indicating nonsignificant variances in mean age between all pairs of procedure groups. However, for BMI, the ANOVA outcomes displayed statistically significant differences across the procedure groups ($F(2, 20312) = 210.97$, $p < 0.0001$), echoing the conclusions drawn in the original investigation.Nonetheless, the ANOVA methodology, along with Tukey's HSD post hoc test, ensured the robustness of the analysis for both age and BMI in the replication study. This alternative approach provided comprehensive evaluations while controlling for multiple comparisons, thereby strengthening the reliability of the results. Consequently, ANOVA emerged as the preferred method for assessing both age and BMI disparities across the procedure groups in the replication study.

Furthermore, the MEA Procedure entails a systematic approach to data analysis that involves using various statistical techniques to measure and estimate parameters of interest within a dataset. In the context of the original study, the MEA Procedure primarily utilized t-tests to evaluate differences in mean age among individuals undergoing different bariatric procedures. However, in light of the limitations of this approach, the replication study sought to refine the methodology by employing ANOVA to provide a more comprehensive assessment of age and BMI variations across the procedure groups. This critical examination of statistical methods underscores the importance of methodological refinement in ensuring the credibility and reliability of research findings. Through rigorous evaluation and implementation of alternative methodologies, the replication study aimed to enhance the validity of its conclusions while adhering to best practices in data analysis.

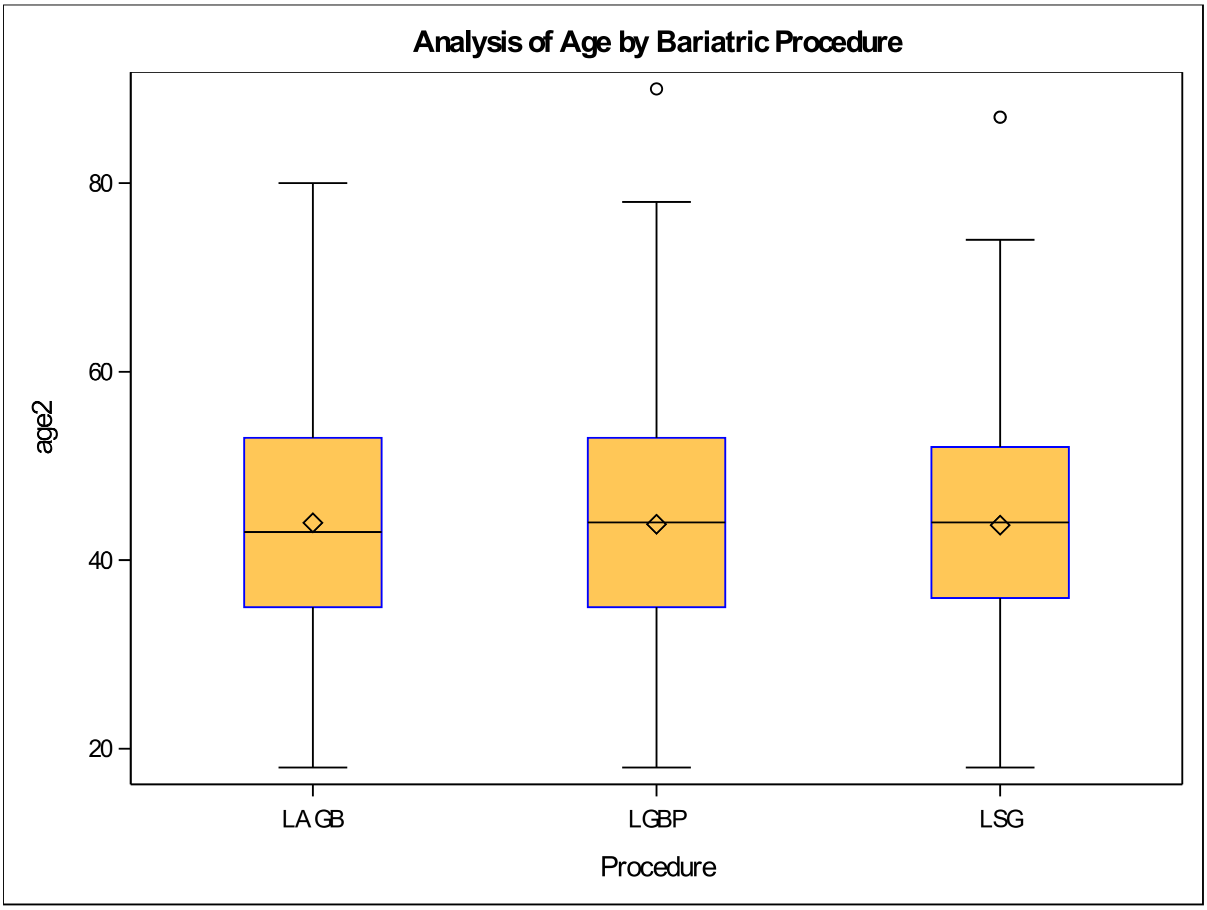


Table 6

Procedure Comparison	**Difference between Means**	**95% Confidence Limits**	**Significance**
LAGB-LGBP	0.15	(-0.29,0.59)	
LAGB-LSG	0.24	(-0.36,0.86)	
LGBP-LAGB	-0.15	(-0.59,0.29)	
LGBP-LSG	0.09	(-0.45,0.65)	
LSG-LAGB	-0.24	(-0.86,0.36)	
LSG-LGBP	-0.09	(-0.65,0.45)	

*No Significant values are found in the above table

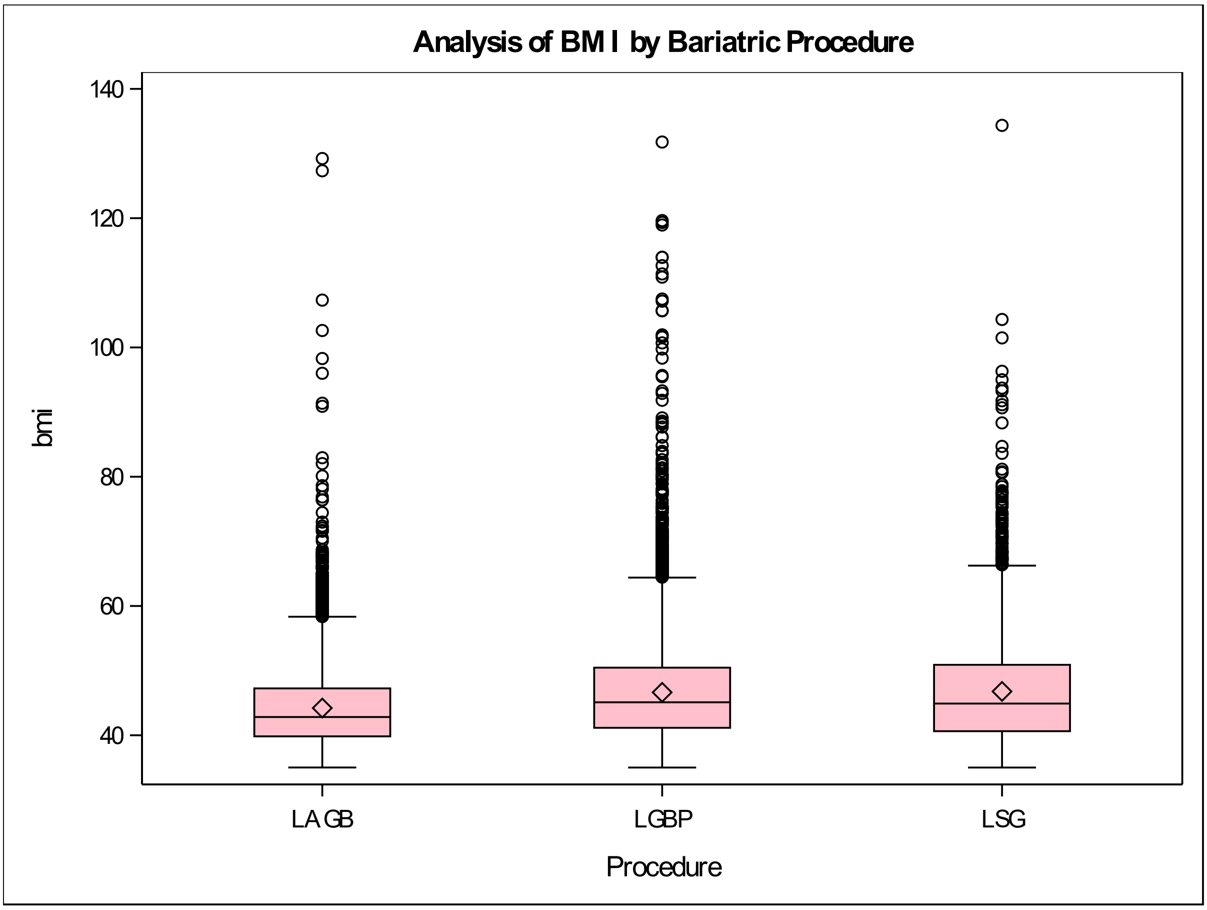


Table 7

Procedure Comparison	Difference between Means	95% Confidence Limits	Significance
LSG-LGBP	0.14	(-0.22,0.50)	
LSG-LAGB	2.57	(2.16,2.97)	***
LGBP-LSG	-0.14	(-0.50,0.22)	
LGBP-LAGB	2.42	(2.13,2.71)	***
LAGB-LSG	-2.57	(-2.97,-2.16)	***
LAGB-LGBP	-2.42	(-2.71,-2.13)	***

(***) Statistically significant

In Table 2 of the original article, the variable OPTIME (Total operation time) underwent analysis initially using the PROC MEANS procedure, which yielded descriptive statistics including mean, minimum, and standard deviation for each surgical procedure (LAGB, LGBP, LSG). However, recognizing the characteristics of the data, particularly the distribution of Operation time across different surgical procedures, an alternative approach, the Kruskal-Wallis test, was considered more suitable. This decision was informed by the observed potential non-normality and variance inequality in the Operation time data, making traditional parametric methods less appropriate. Similarly, for the total length of stay variable, the initial method used was the PROC UNIVARIATE procedure. This method was chosen to analyze the total length of stay variable, providing descriptive statistics and tests for location based on parametric assumptions. However, upon closer examination of the data's characteristics, particularly the length of stay variable across different surgical procedures, the Kruskal-Wallis test was deemed more appropriate. This decision stemmed from the observed potential skewness and non-normality in the total length of stay data, rendering traditional parametric tests less suitable. Therefore, considering the specific characteristics of both the Operation time and total length of stay data, including non-normal distributions and likely variance inequalities among surgical procedures, the Kruskal-Wallis test emerges as a robust and suitable method for analyzing and comparing these variables among the different groups.

Measurement and Evaluation Analysis (Table 8)

Table 2 Postoperative complications				
Variable	*LGBP	*LAGB	*LSG	P-value
Operation time, median (IQR)	126 (63)	62.3 (32)	92.6 (49)	**<0.0001**
Length of stay, median (IQR)	2.4 (1.0)	1.0 (1.0)	2.6 (1.0)	**<0.0001**

*Laproscopic Gastric By-pass
*Laproscopic gastric banding
*Laproscopic sleeve gastrectomy
***Bold indicate statistically significant**

Theory of Change Analysis:

The logistic regression analysis unveiled significant links between diabetes status (diabetes: Insulin, Non-insulin, and No diabetic) and diverse wound complications after bariatric surgery. Individuals with diabetes, encompassing both insulin and non-insulin-dependent cases, displayed a notably elevated occurrence of superficial surgical site infections (SUPINFEC) in comparison to those without diabetes ($p < 0.0001$). However, no substantial differences were evident among the three groups concerning deep incisional SSI (WNDINFD), organ space SSI (ORGSPCSSI), wound dehiscence, and wound disruption (DEHIS), signifying a lack of significant associations between diabetes and these postoperative complications.

These findings underscore the intricate interplay between diabetes and specific wound complications post-bariatric surgery, emphasizing the necessity for further research to unveil underlying mechanisms and devise tailored interventions. Despite the statistical analysis not indicating a significant link between diabetes status and certain wound complications post-bariatric surgery, it's imperative to consider the broader context. Diabetic wounds tend to undergo a prolonged healing process compared to non-diabetic wounds, potentially leading to additional complications (Spampinato, S.F., et al., 2020). As the healing process encompasses distinct phases—namely, inflammatory, proliferative, and remodeling—each characterized by unique cellular and molecular events, diabetic wounds may exhibit dysregulation in these phases, resulting in impaired healing (Spampinato, S.F., et al., 2020). Further exploration is essential to understand the underlying mechanisms. Gaining insight into how diabetes influences wound healing phases post-bariatric surgery could offer valuable perspectives for crafting targeted interventions to mitigate complications in diabetic patients undergoing such procedures.

Table 9. Theory of Change Analysis: Effect of Diabetes on Wound Complications

Wound Type	Odds ratio	95% CI	P-value
Superficial site infection	Insulin vs No Diabetes 2.42 Non-Insulin vs Diabetes 1.38	(1.74,3.36) (1.00,1.89)	**<0.0001** 0.0452
Deep site infection	Insulin vs No Diabetes 0.60 Non-Insulin vs Diabetes 1.14	(0.17,2.10) (0.33,3.95)	0.4320 0.8322
Organ space site infection	Insulin vs No Diabetes 1.47 Non-Insulin vs Diabetes 0.84	(0.79,2.73) (0.46,1.53)	0.2167 0.5871
Wound dehiscence	Insulin vs No Diabetes 0.82 Non-Insulin vs Diabetes 1.3	(0.10,6.42) (0.36,4.77)	0.8516 0.6793

*Bold are statistically significant

The association between diabetes and wound complications in bariatric surgery presents a multifaceted scenario, influenced by both age and body mass index (BMI). With age progression and BMI increase, the intricate interplay between diabetes and post-bariatric surgical outcomes gains complexity. Employing logistic regression and the iterative backward elimination method, this study aimed to untangle the web of predictors shaping these outcomes. Examining wound complications like superficial and deep incisional surgical site infections (SUPINFEC and WNDINFD), organ/space surgical site infections (ORGSPCSSI), and wound disruption (DEHIS), the analysis scrutinized the effects of age, BMI, and diabetes. Through systematic elimination of non-significant predictors, the study sought to identify the most influential factors in predicting postoperative outcomes.

In the context of SUPINFEC, both BMI and diabetes retained significance after elimination, highlighting their crucial roles in shaping post-bariatric surgical outcomes. Specifically, higher BMI correlated with increased odds of SUPINFEC, while diabetes increased likelihood of superficial site infection.

Conversely, deepsite infection and wound dehiscence analysis identified BMI as the sole significant predictor post-elimination, emphasizing its substantial impact on wound outcomes. The association between BMI and deepsite infection shows a decrease in deepsite infection with increasing BMI. The converse is true with wound dehiscence, increasing BMI is associated with increased odds of wound dehiscence.

However, neither age, BMI, nor diabetes remained significant predictors for ORGSPCSSI after elimination. This nuanced finding suggests that while these factors play pivotal roles in certain wound complications, other intricate variables may contribute to the overall surgical outcome complexity.

In summary, a significant association was found between diabetes and superficial site infection in bariatric surgery after adjusting for age and BMI. Through the backward elimination method, this study sheds showed significant associations between diabetes, BMI and wound complications in post-bariatric surgery.

Table 10. Theory of Change Analysis : "Multivariate Logistic Regression using Backward Selection for wound complications"

Response variable	Removed effects	Significant predictors	Odds ratio (95% CI)	P-value
Superficial site infection	Age	BMI	1.03(1.01, 1.04)	**<.0001**
		Diabetes	1.73(1.34,2.22)	**<.0001**
Deepsite infection	Diabetes, Age	BMI	0.95(0.93,0.97)	0.004
Organspace site infection	Diabetes, Age, BMI	None		
Wound dehiscence	Age, Diabetes	BMI	1.05(1.00,1.09)	**0.01**

*Bold indicate statistical significance

Table 11. Theory of Change Analysis : "Postoperative wound complications by wound type and Diabetic status"

Wound Type	Insulin	Non-insulin	Non-Diabetic	p-value
Superficial site infection	47(2.57%)	51(1.48%)	162(1.08%)	**<.0001**
Deep site infection	3(0.16%)	3(0.09%)	15(0.10%)	0.6856
Organ space site infection	12(0.66%)	13(0.38%)	67(0.45%)	0.3476
Wound dehiscence	1(0.05%)	3(0.09%)	10(0.07%)	0.8963

*Bold indicate statistical significance

Discussion:

The replication study is a crucial process that aims to validate the findings of a previous research study on postoperative complications in bariatric surgery patients using age and BMI stratification. The study's primary objective is to confirm the significant associations between age, BMI, and wound complications found in the previous research, and to provide further evidence of the association between age, BMI, and postoperative wound complications in bariatric surgery patients with diabetes (diabetic, non-diabetic, non-diabetic).

The replication study consists of three analyses that validate the results of the previous research, ensuring its reliability and validity. Additionally, the replication study explores the association between wound complications and diabetes status, which is a crucial factor to consider when selecting patients for bariatric surgery. The findings reinforce the need for careful patient selection, emphasizing the importance of assessing patients' overall health status before undergoing bariatric surgery.

One of the replication study's significant contributions is the use of additional analysis methods, such as ANOVA and Kruskal Walli's tests, to expand on the original study's findings. These methods provide new insights into demographic differences among surgery categories, further supporting the need for careful patient selection. Additionally, the Theory of Change Analysis (TCA) revealed a new association between wound complications and diabetes status, adding a valuable dimension to the original research.

The replication process confirms the validity and reliability of the original study's conclusions, increasing confidence in the results. The findings of the replication study provide valuable information to healthcare professionals, surgeons, and researchers, helping them make informed decisions when selecting patients for bariatric surgery. Overall, the replication study is an essential process that validates and expands on the previous research, providing further evidence of the association between age, BMI, and postoperative complications in bariatric surgery patients.

While the replication study largely validated the original findings, there were some differences noted between the two studies. These variations could be attributed to several factors, including differences in sample populations, variations in analytical approaches, or inherent variability in the data. It's important to emphasize that these differences do not necessarily indicate errors in either study but rather highlight the complexities involved in replicating research findings.

One significant difference was the utilization of alternative analysis methods in the replication study, such as ANOVA for demographic comparisons. In contrast, the original study primarily relied on t-tests and chi-square tests. The inclusion of ANOVA and Kruskal Walli's tests in the replication study offered additional insights into the relationships among variables across different surgery categories. This variation underscores the importance of exploring multiple analytical approaches to ensure the robustness of research findings.

In addition, the Theory of Change Analysis (TCA) integrated into the replication study unveiled new perspectives regarding the link between wound complications and diabetes status, a facet not explicitly investigated in the original research. This supplementary analysis enhances the study's relevance in the field by revealing novel associations and plausible intervention strategies.

It is imperative to recognize that despite the rigorous replication process, several limitations need to be taken into account. One of the main limitations is that the replication study was dependent on the availability of raw data from the original research. The use of this data may introduce some degree of variability in the results as the data may have been subjected to different methods of organization, and analysis. Moreover, since the data is exclusively derived from the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP), the applicability of the findings to different populations or environments might be limited. Although ACS NSQIP covers a wide range of hospitals, its emphasis is primarily on surgical patients within these specific hospital contexts.

Furthermore, while the replication study aimed to replicate the original analyses accurately, minor discrepancies may arise due to differences in data handling or interpretation. This is because the replication process requires that the same statistical methods and criteria be used as in the original study, which may not be entirely possible in practice. Also, upon careful review of the bariatric surgery article, finding complete data to reproduce the morbidity variable and its corresponding p-value was difficult because the original paper did not clearly define the morbidity variable. Likewise, the postoperative complications variable was undefined in the original article. As such, any discrepancies that arise may have an impact on the validity and reliability of the results.

In addition, the generalizability of the findings may be limited to the specific population and settings included in the original study. The primary difficulty in replicating the study stemmed from the lack of clear definitions for certain variables, such as the morbidity variable and postoperative complications variable in the original research. This lack of clarity made it challenging to precisely replicate these aspects of the study. Specifically, defining morbidity as a binary variable based on a specific cutoff point was not possible as no such cutoff was provided in the original paper. Similarly, the postoperative complications variable was undefined, further complicating the replication process. Moreover, obtaining complete data to reproduce these variables was difficult due to the absence of clear definitions.

Public Health Implications:

The study extensively examined the relationship between age, BMI, and postoperative complications in individuals undergoing bariatric surgery, placing special emphasis on how diabetes status influences wound complications. By employing rigorous statistical analyses and thorough replication procedures, the study yielded invaluable insights into the risk factors linked with bariatric surgery and their subsequent impact on patient outcomes.

The study's results hold substantial implications for public health, especially concerning healthcare providers responsible for selecting and managing patients undergoing bariatric surgery. The identification of age, BMI, and diabetes status as critical risk factors for postoperative complications underscores the necessity for comprehensive preoperative assessments and careful patient selection to minimize risks and enhance outcomes.

Moreover, the study's thorough replication process highlights the critical importance of employing robust research methods and validating findings within scientific research endeavors. The replication study, which largely affirmed the original findings, serves further to bolster the reliability and validity of the research conclusions.

In summary, agreement with the original study's conclusions is evident, which underscores the paramount significance of adhering to stringent patient selection criteria, conducting comprehensive preoperative screenings, and providing tailored care to mitigate the risk of postoperative complications among bariatric surgery patients. These insights offer valuable guidance for healthcare practitioners, policymakers, and researchers, paving the way for improvements in patient care and outcomes within this population.

References:

Ma, I. T. (2015). Gastrointestinal Complications After Bariatric Surgery. *Gastroenterology & Hepatology*, *11*(8), 526-535. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4843041/

Sanni, A., Perez, S., Medbery, R. *et al.* Postoperative complications in bariatric surgery using age and BMI stratification: a study using ACS-NSQIP data. *Surg Endosc* **28**, 3302–3309 (2014). https://doi.org/10.1007/s00464-014-3606-7

Spampinato, S. F., Caruso, G. I., Pasquale, R. D., Sortino, M. A., & Merlo, S. (2020). The Treatment of Impaired Wound Healing in Diabetes: Looking among Old Drugs. *Pharmaceuticals*, *13*(4). https://doi.org/10.3390/ph13040060

Appendix:

```
/*SAS Code*/
/*Dataset*/
LIBNAME mylib '/home/u61325000/sasuser.v94';
data capstone;
set mylib.sanni;
if age ='90+' then age2=90;
else age2=10*age/10;
if DIABETES in ("INSULIN", "NON-INSULIN") then
      diabetes4 = "Yes";
   else if DIABETES = "NO" then
      diabetes4 = "No";

   if CPT= '43644' then Procedure='LGBP';
   else if CPT= '43770' then Procedure='LAGB';
   else if CPT= '43775' then Procedure='LSG';
   if  CPT= '43644' then Procedure2='2';
```

```
   else if CPT= '43770' then Procedure2='0';
   else if CPT= '43775' then Procedure2='1';
if DOpertoD = -99 then mortality=0;
else mortality = 1;

if noupneumo = "1" or reintub = "1" or pulembol="1" or failwean="1" or renainsf="1"
or urninfec="1" or cdmi="1" or cdarrest="1" or nothbleed="1" or RENAFAIL="1" or
NOTHDVT="1" or neurodef="1" or dcnscoma="1" or cnscva="1" or mortality = "1"
then complication=1;
else complication=0;
if ASACLAS = 'None assigned' then ASACLAS=.;
if ASACLAS = "1-No Disturb" or ASACLAS = "2-Mild Disturb" then NewClass = 0;
else if ASACLAS = "3-Severe Disturb" or ASACLAS = "4-Life Threat" then NewClass
= 1;
if hxcopd ne "NULL";
if dyspnea = "No" then dyspnea2=0;
else dyspnea2 = 1;
if hypermed ne "NULL";
if diabetes = "NO" then diabetes3=0;
else diabetes3=1;
run;


/* Proc contents */
proc contents data=capstone;
run;
PROC PRINT DATA=CAPSTONE (OBS=50);
RUN;



/*Measurement and Estimation Analysis*/
/*Doubt table 1 : age bmi*/
/*table 1: sex race inpatient asa*/
/*table-1 age*/
/*Original Article*/
proc means data=capstone;
class procedure;
var age2;
run;
proc freq data=capstone;
tables sex*procedure asaclas*procedure inout*procedure race_new*procedure;
run;
/*Alternate Method*/
proc glm data=capstone plots(MAXPOINTS=20000); /* Increase the cutoff to 20000 */
   class procedure;
   model Age2 = procedure;
   means procedure / Tukey;
 title 'Analysis of Age by Bariatric Procedure';
run;
```

```
/*for Boxplot*/
ods rtf file="/home/u61325000/capstone.rtf4";
proc sgplot data=capstone;
   vbox Age2 / category=procedure
            groupdisplay=cluster
            lineattrs=(color=blue)
            fillattrs=(color=lightbrown);
            title  'Analysis of Age by Bariatric Procedure';
run;
ods rtf close;

/*table 1 bmi*/
/*Orginal Article*/
proc means data=capstone;
class procedure;
var bmi;
run;
/*Alternative Method*/
proc glm data=capstone;
   class procedure;
   model bmi = procedure;
   means procedure / tukey; /* Tukey's post hoc test for pairwise comparisons */
  title  'Analysis of Age by Bariatric Procedure';
run;
/*For Boxplot*/
ODS RTF FILE="/home/u61325000/Caps.rtf";
proc sgplot data=capstone;
   vbox BMI / category=procedure
            groupdisplay=cluster
            lineattrs=(color=blACK)
            fillattrs=(color=PINK);
            title  'Analysis of BMI by Bariatric Procedure';
run;
ODS RTF CLOSE;

/*table 2 */
/*No Morbidity Variable*/
/*mortality*/
data updated;
set capstone; /* Replace your_dataset with your actual dataset name */
if YRDEATH in (2010, 2011) then YRDEATH_GROUPED = "2010-2011";
else if YRDEATH = -99 then YRDEATH_GROUPED = "-99";
else YRDEATH_GROUPED = "Other"; /* Adjust based on how you want to handle other
years */
run;
proc freq data=updated;
tables YRDEATH_GROUPED*procedure / chisq  missing;
title "Frequency of YRDEATH_GROUPED by CPT";
run;
/*reoperation*/
```

```
proc freq data=capstone;
table returnor*procedure/chisq;
run;
/*OPtime*/
/*Original Data Method*/
PROC MEANS DATA=capstone mean min std ;
    CLASS procedure;
    VAR Optime;
    RUN;
/*Alternative Method*/
proc npar1way data=capstone;
 class procedure;
 var optime;
 run;
proc univariate data=capstone;
   class Procedure;
   var optime;
 run;
/*Length of stay*/
/*Original Data Methods*/
proc univariate data=capstone nextrobs=0;
 class procedure;
   var tothlos;
   output out=location
          mean=Mean mode=Mode median=Median
          q1=Q1 q3=Q3 p5=P5 p10=P10 p90=P90 p95=P95
          max=Max;
run;
/*Alternative Method*/
proc npar1way data=capstone;
 class procedure;
 var tothlos;
 run;
proc print data=location noobs;
run;
proc univariate data=capstone;
   class Procedure;
   var tothlos;
 run;


/*table 3*/
PROC FREQ DATA=capstone;
    TABLES noupneumo*procedure ReIntub*procedure Pulembol*procedure
           FailWean*procedure  RenaInsf*procedure
           Urninfec*procedure
           nothdvt*procedure /chisq;
             RUN;
proc freq data=capstone;
```

```
tables cdmi*procedure nothbleed*procedure Cdarrest*procedure neurodef*procedure
dcnscoma*procedure noprenafl*procedure cnscva*procedure/fisher;
run;

/*table 4*/
/*wound complications*/
/*superficial*/

proc freq data=capstone;
tables supinfec*procedure/chisq;
run;

/*Deep Space Infection*/
proc freq data=capstone;
table wndinfd*procedure/chisq;
run;

/*Organ space site infection*/
proc freq data=capstone;
table ORGSPCSSI*procedure/chisq;
run;

/*wound dehiscence*/
/*As sample size is small used Fisher's exact test*/
proc freq data=capstone;
tables dehis*procedure/fisher;
run;

/*Figure 1*/
/*Multiregression Model*/
proc logistic data=capstone;
class procedure2 (param=ref ref='0');
class ASAClass (param=ref ref='0');
class hxcopd (param=ref ref="No");
class dyspnea2 (param=ref ref='0');
class hypermed (param=ref ref="No");
class diabetes3 (param=ref ref='0');
class mortality (param=ref ref='0');
/*class wound (param=ref ref='0')*/;
model complication(event="1") =procedure2 age2 bmi ASAClass hxcopd dyspnea2
hypermed diabetes3
/clodds=pl;
TITLE "LOGISTIC MODEL RESULTS";
run;

/*Theory of Change Analysis*/
/*Diabetes is categorized as Insulin, Non-Insulin, and No-Diabetic*/
/*1.Association between wound complications and diabetes*/
proc logistic data=CAPSTONE DESC;
  class  DIABetes (param=ref ref="NO");
```

```
  model supinfec = DIABetes  ;
  run;
  proc logistic data=CAPSTONE DESC;
  class  DIABetes (param=ref ref="NO") ;
  model wndinfd = DIABetes  ;
  run;
  proc logistic data=CAPSTONE DESC;
  class  DIABetes (param=ref ref="NO");
  model ORGSPCSSI = DIABetes ;
  run;
  proc logistic data=CAPSTONE DESC;
  class  DIABetes ( param=ref ref="NO");
  model dehis = DIABetes ;
  run;
/*Freqency tables for Wound complications*/
 /* Superficial Site Infection*/
  proc freq data=capstone;
  tables supinfec*diabetes/chisq;
  run;
 /*Deep site Infection*/
 proc freq data=capstone;
  tables wndinfd*diabetes/fisher;
  run;
/*Organ Space Site Infection*/
proc freq data=capstone;
tables orgspcssi*diabetes/chisq;
run;
/*Wound dehiscence*/
proc freq data=capstone;
tables dehis*diabetes/fisher;
run;

 /*2.Multiregression Logistic MOdel using Age, BMI, and Diabetes for Wound
Complications*/
  /* Backward selection for supinfec */
proc logistic data=CAPSTONE;
    class DIABetes4 (param=ref ref="No");
    model supinfec = BMI DIABETES4 AGE2 / selection=backward slstay=0.05;
    run;

/* Backward selection for wndinfd */
proc logistic data=CAPSTONE;
    class DIABetes4 (param=ref ref="No");
    model wndinfd = BMI DIABETES4 AGE2 / selection=backward slstay=0.05;
    run;

/* Backward selection for ORGSPCSSI */
proc logistic data=CAPSTONE;
    class DIABetes4 (param=ref ref="No");
    model ORGSPCSSI = BMI DIABETES4 AGE2 / selection=backward slstay=0.05;
```

```
   run;

/* Backward selection for dehis */
proc logistic data=CAPSTONE;
   class DIABetes4 (param=ref ref="No");
   model dehis = BMI DIABETES4 AGE2 / selection=backward slstay=0.05;
   run;
```